growing season and after harvest when the pit stores are prepared and filled. details are given in Annex IV. The secondary information collected from farmers at the beginning of the season should be with DAI staff by June/July so that it can be used to develop a strategy for the end of season post-harvest operations. Mr Khalid Farooq, Production Manager of Jaffer Brothers should be used as a resource person due to his experience with potato storage in Kalam.

ITINERARY

<u>February</u>

3	Depart London
4	Arrive Islamabad. Meeting O/AID/REP, Fred Smith and Ray Renfro
5	Public holiday. Prepare materials for training course
6	Travel to Peshawar. Meet with DAI staff for discussions on training. Preparation of materials
7	Office closed
8	Finalize course program and lectures.
9	Training course
10	Training course
11	Training course
12	Training course
13	Training course
14	Office closed
15	Preparation of training materials
16	Preparation of materials for training and on-farm trials. Report drafting
17	Preparation materials for extension work
18	Extension materials. Report drafting
19	Travel to Islamabad. Debriefing O/AID/REP, Fred Smith and Gary Lewis
20	Report writing
21	Depart Islamabad

Annex I

POTATO QUESTIONS FOR COURSE EVALUATION

1. Q. What is the best physiological stage to plant seed tubers and why?

   a. Dormancy

   b. Multiple sprouting

   c. Apical dominance

   A. b. Multiple sprouting. Gives rapid emergence and good initial growth. More stems per unit area, better ground cover, and therefore higher yield.

2. Q. Why is it risky to plant dormant seed tubers?

   A. Emergence is delayed and uneven. Greater chance of seed tubers and sprouts becoming infected. Gives rise to a non-uniform crop.

3. Q. What is the advantages of cutting seed tubers?

   A. Use less seed tubers to plant the crop (lowers the cost of inputs). Will hasten emergence and increase the number of stems if tubers have not reached the multiple sprouting stage.

4. Q. What problems can arise with cutting seed tubers?

   A. Can spread diseases with the cutting knife (PVX, PVY, bacterial diseases). Seed piece decay due to easy entry of soil-borne pathogens via the cut surface. Seed piece will dry out if planted in dry soil or soil not kept moist after planting. Often the number of eyes on each seed piece is too small.

5. Q. What are the advantages of rapid emergence of the potato crop?

   A. Less likelihood of tuber/seed piece decay or of the sprouts being attacked by soil- and tuber-borne pathogens such as <u>Rhizoctonia</u>.

6. Q. When should NPK fertilizer be applied to the crop?

A. PK and half the N at land preparation/planting time. The second application of N as urea at final ridging.

7. Q. What damage do aphids do to the potato crop? Should insecticide spray be used to control them?

A. They transmit virus diseases--leafroll and PVY. Aphids do not do any direct damage. It is not possible to stop the spread of the virus diseases through control of the vectors in the crop.

8. Q. Which disease occurs at temperatures below 20^0C?

a. Late blight (Phytophthora infestans)

b. Early blight (Alternaria solani)

What other weather conditions are necessary for spread of the disease?

A. Late blight. Warm, wet (at least water--moisture, dew--available on the leaf surface), overcast (sun not going to dry out the leaf surface), wind and/or rain to transfer spores to other plants in the crop.

9. Q. Why do losses occur to potatoes stored in pits in the ground?

A. Lack of ventilation. No through air to keep temperature down and the surface of the tubers dry. Results in overheating and increased respiration which favors sprout growth after the dormant period. Damp warm tubers (lenticels open) more susceptible to attack by fungi and bacteria which cause rotting.

10. Q. How can farmers improve the quality of their own seed potatoes?

A. Mark healthy-looking (no symptoms of virus diseases or wilts) plants with sticks, collect the tubers from these plants, and grow as a separate plot the following season. Repeat the process until the percentage of disease in the crop falls to an acceptable level.

11. Q. What is the effect of lack of irrigation after planting?

A. Soil becomes dry, gives irregular emergence, reduced stem number and therefore reduced yield. Cut seed pieces can dry out and fail to emerge.

12. Q. If the soil is dry, should the farmer irrigate his field:

a. Before preparing the ridges?

b. After preparing the ridges but immediately before planting?

c. After planting?

A. a. Before preparing the ridges so that the soil in the ridges is uniformly moist. Irrigating immediately before placing the tubers/cut tubers in wet soil is not as good.

Annex II

LECTURE HANDOUTS: POTATO COURSE FOR DAI EXTENSION AGENTS

(Extensive use was made of the International Potato Center's Technical Information Bulletins, from which the diagrams are also taken, and Introduction to Potato Production by H.P. Beukema and D.E. van der Zaag)

PLANTING POTATOES

Farmers should realize that once potatoes have been planted the yield is already largely determined. The factors having a major effect on yield, and already determined are:

1. Seed bed (soil) preparation
2. Planting procedure
3. Planting depth
4. Condition of the seed tuber--both health-wise and physiological
5. Seed rate--seed tuber/piece size and planting distance
6. Fertilizer rate
7. Ridging and weed control

After crop emergence, the three most important factors influencing yield are second earthing-up, water management and disease and pest control.

Seed bed preparation

Seed tubers should be planted in fairly moist, loose soil. If it is too loose or cloddy, it will dry out too easily. There should be no compacted layers under the seed bed that cannot be penetrated by the weak root system of the potato plant; deep rooting is important for good water supply to the crop.

A good seed bed ensures sufficient

- oxygen for the underground parts of the plant,
- moisture retention, and
- drainage of water,

and leads to good growth of the roots and stolons and production of well-formed tubers.

Planting procedure

Planting should meet the following requirements:

- Seed tubers should be placed in moist, but not wet, soil that will not dry out before the tubers are covered.

- Seed tubers should lie at an even and correct depth and fairly accurately spaced in the row.

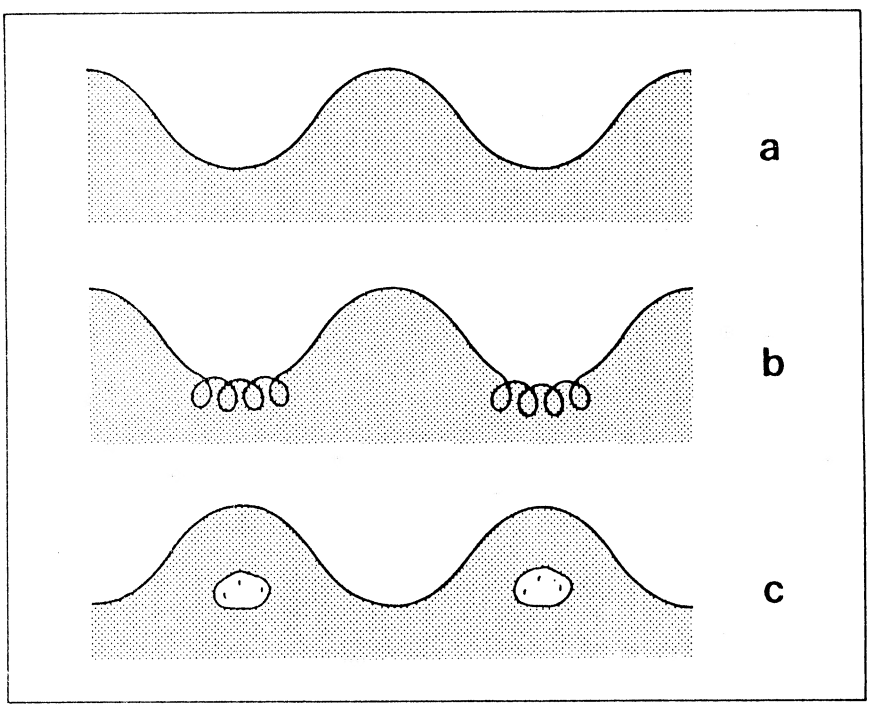
- Seed tubers should not be indirect contact with fertilizers

- Sprouts of pre-sprouted tubers should not be damaged.

Planting by hand can be as good as or even better than planting by machine. Tubers can be planted in either furrows or ridges.

Planting in furrows

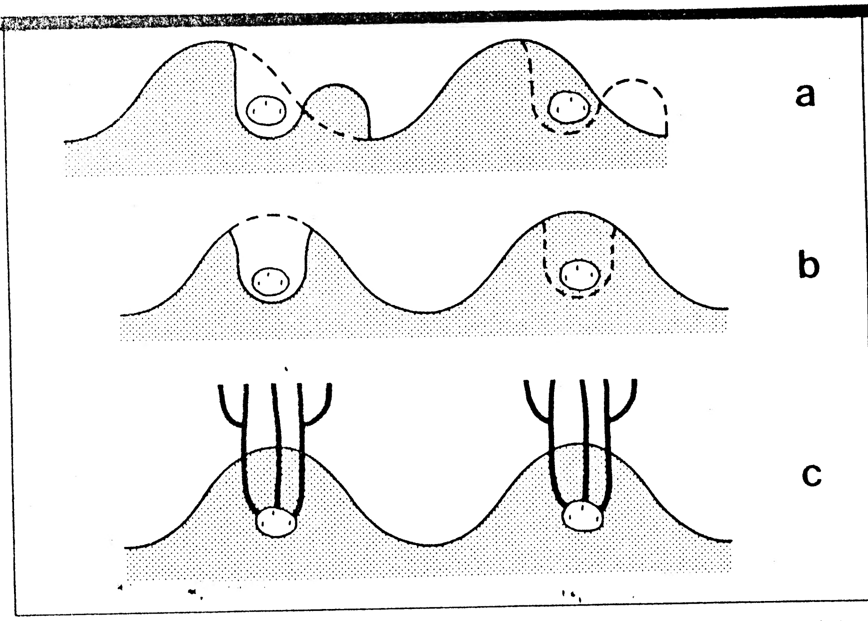
[TIB 11: planting Potatoes. Diagram page 15]



Planting in furrows: form the furrows (a), mix the fertilizer with soil (b), plant the seed tubers and cover them (c).

Planting in single ridges by opening auxiliary furrows or individual holes.

[TIB 11: Planting Potatoes. Diagram page 16]



Planting in ridges: plant the seed tubers on the side (a) or at the center (b) of the ridges by opening auxiliary furrows or individual holes. Ridges after hilling (c).

Planting on double ridges is practiced by many farmers.

Planting depth

Adjust the planting depth to the more important factor, either soil moisture or soil temperature.

Adjustment for soil moisture. When the soil is dry, plant deep. When the soil is wet, plant shallow.

Adjustment for soil temperature. During the day the soil is warmer at the surface. When the soil is warm, plant deep. When the soil is cool, plant shall shallow.

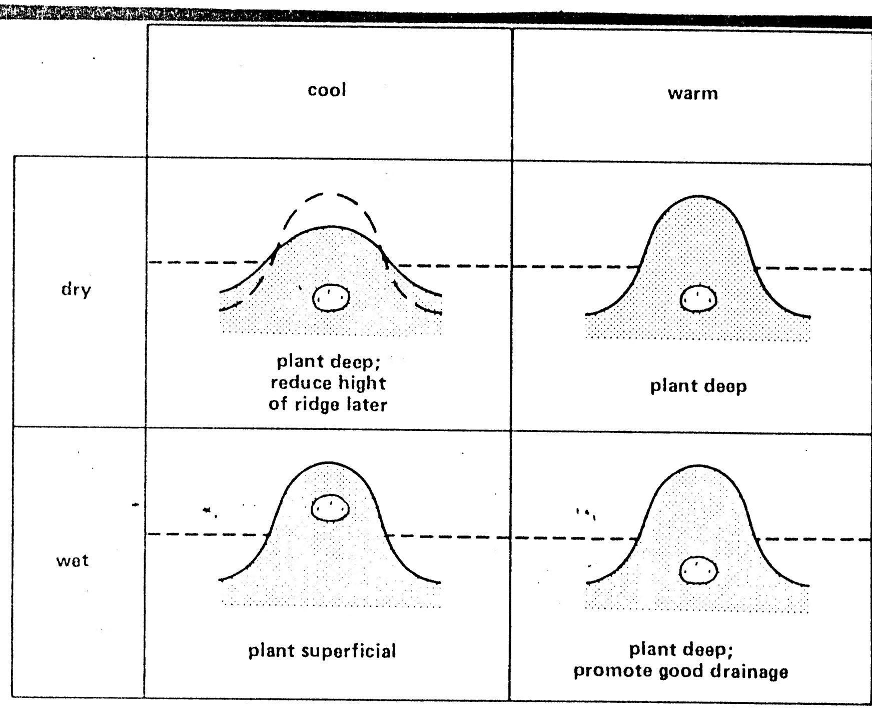
Deep planting also protects the tubers from diseases and pests such as late blight and potato tuber moth, and prevents tuber greening when tubers are exposed to the light.

Superficial planting, while making the tubers more accessible to pests and diseases and increasing the chance of greening, does facilitate harvesting. A pre-requisite for shallow planting is that there will be moist soil around the seed tuber and the

necessary conditions for making a well-shaped, high ridge after planting.

Large tubers are more adaptable to deeper planting than small tubers. Shallow planting of small tubers and seed pieces, followed by high ridging may be a good way to regulate planting depth.

[TIB 11: Planting Potatoes. Diagram page 11]



Adjust the planting depth to the most important factor, soil moisture or soil temperature.

Planting distance

Planting distance depends on variety, growing conditions and desired tuber size at harvest. If soil fertility or moisture is low, the soil can maintain fewer plants. The higher the crop density, the smaller will be the size of the harvested tubers.

The distance between rows depends on local practice, available implements and growth habit of the variety.

A wide distance between rows:

- provides more soil for ridging,
- prevents damage to roots, stolons and tubers during cultivation, and
- facilitates roguing in seed crops.

A narrow distance between rows:

- ensures that irrigation water reaches all roots, and
- increases efficiency in the use of land, nutrients (fertilizer), water and light.

Importance of correct planting

Correct planting ensures:

- rapid emergence, and
- uniformity of the crop.

Rapid emergence reduces the time that sprouts are exposed to danger from soil pests and diseases. The decay of seed tubers, and especially cut seed pieces, is reduced.

Crop uniformity is important for ensuring even ground cover (maximizing light utilization, reducing soil water loss, weed control, etc.) and making cultivation practices (ridging, irrigation, spraying, and harvesting) easier.

Both rapid emergence and crop uniformity are greatly influenced by the physiological condition of the seed tubers at planting.

1. Introduction

1.1 The present visit to Pakistan is the second part of a consultancy to help DAI develop a potato improvement program that will become operational in the 1992 growing season. The first visit during July/August 1991 concentrated on appraising the current situation and developing a strategy for improvement of the crop.

1.2 Constraints to productivity improvement in Afghanistan fall into three broad categories: cultural practices, seed improvement, and storage. These topics have been targeted during the training of the DAI extension agents and preparation of their work programs for the 1992 growing season.

1.3 A training component was included in the strategy for potato improvement. The DAI extension agents have received a one-week intensive course on production methods, and this should allow them to identify deviations from "recommended" cultural practices that may require changing or fine-tuning.

1.4 Poor quality seed tubers that farmers keep year after year are by far the most important reason why yield levels are low. The local varieties Garma and Sarda were introduced over fifty years ago and there are no records of further introductions. Stocks of the varieties are now degenerate due to infection by virus diseases.

1.5 In the first year of the program, upgrading of the farmers' seed stocks will be tackled in two ways; (1) importing and testing variety Diamant in on-farm trial/demonstration plots, and (2) assisting farmers to improve their own seed material by on-farm selection.

1.6 Post-harvest problems revolve around losses in storage and, in discussions with the extension agents, it became apparent that little knowledge was known about storage details and actual losses. Much more information is required before a successful program can be designed to look at ways of cutting down on losses in pit storage.

2. Training

2.1 Training course

2.1.1 The potato training course was held at the Agricultural Training Institute, Peshawar from February 9 to 13. It was attended by about 100 DAI Afghan extension agents,

CUTTING POTATO SEED TUBERS

In many countries, seed cutting is done, especially if the seed tuber size is large. This is done to:

- save seed and improve the multiplication rate
- increase the number of stems per seed tuber
- stimulate sprout growth

Method of cutting. A sharp knife must be used for cutting so as to damage the minimum number of cells.

There are more eyes at the rose end than at the heel (stem) end at which the tuber is connected to the stolon. Therefore, when cutting a tuber into two pieces, the cut should be from the rose to heel end so as to distribute the eyes evenly between the two halves. Cuts should be made so as to distribute the eyes as evenly as possible, with a minimum of 2-3 eyes per piece.

Wound healing. By promoting healing of the cut surface, seed piece decay can be prevented. After cutting, the superficial cells suberize and wound periderm is formed beneath the suberized layer. The time needed for the formation of the periderm layer depends on:

- variety
- age of tubers
- temperature
- humidity
- oxygen content of the atmosphere

Wound healing is normally complete in 3-5 days in a moist atmosphere (cover trays or baskets of cut seed tuber with damp sacks) with sufficient oxygen and a temperature of approximately 15^0C.

Treating the cut surface with a fungicide dust containing at least 15% carbamate (e.g. Dithane M45) may also help to reduce seed piece decay. Finely ground rice hull, ash, kaoline or talcum can be used as a filler (approximately 4 parts filler to 1 part fungicide).

If conditions at planting are favorable (moist soil, temperature 10^0-18^0C), cutting can be done immediately before planting; the cut surface should then heal quickly enough in the ground.

At planting the seed piece should be placed with the cut surface downward.

Implications of cutting seed tubers. By comparing the productivity of cut seed tuber pieces and whole tubers of the same weight, it is usually found that whole seed tubers give better yield. A whole seed tuber has more skin surface than a cut seed piece and consequently can produce more stems.

If seed tubers are dormant or in the apical dominance stage, cutting may lead to earlier emergence an development of more stems per seed tuber. In this case the use of cut seed pieces can give better results when the same weight of tubers is planted per square meter.

Normally the percentage emergence is lower if cut seed tubers are used, because of "seed piece decay". In general, the percentage emergence is inversely proportional to the size of the cut seed pieces. Another disadvantage of cutting is the transmission of diseases with the knife; e.g., potato viruses S, X, and Y, ring rot (Corynebacterium sepedonicum), black leg (Erwinia spp.) and bacterial wilt (Pseudomonas solanacearum). Transmission of these diseases can be partly remedied by disinfecting the knife between cutting different tubers.

Cutting should never be done if no great benefit is expected. When sol conditions are unfavorable (e.g., dry wet, hot, very cold) or the seed is physiologically old, cutting should never be practiced.

POTATO SEED TUBER PHYSIOLOGY

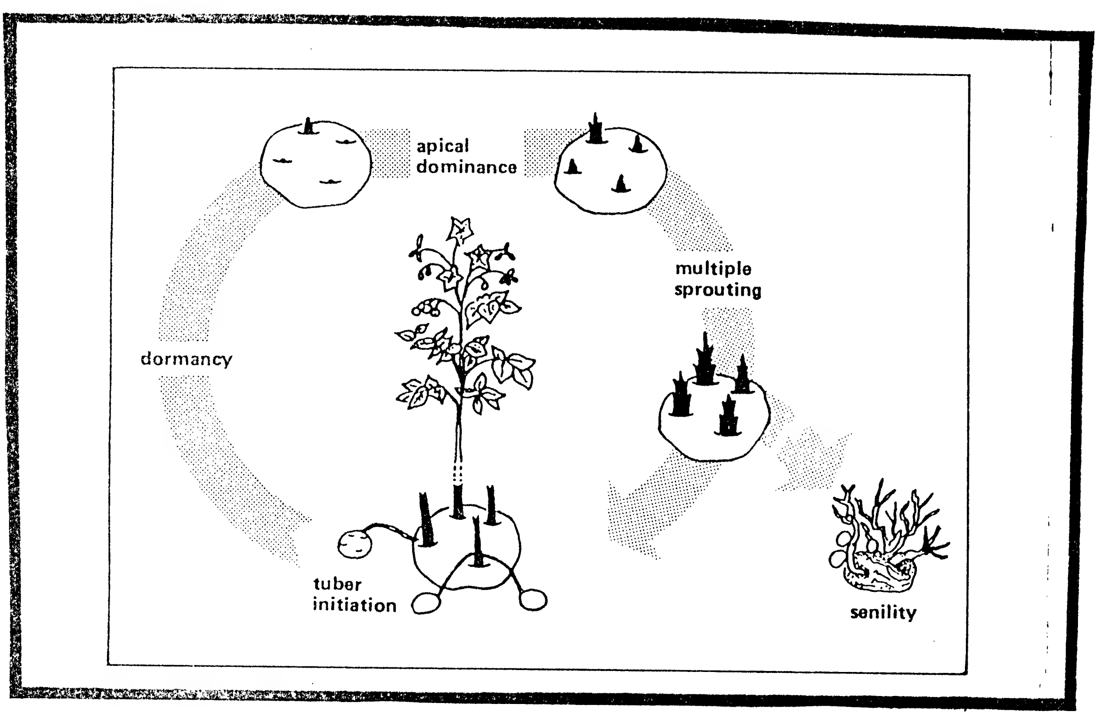
After initiation, a potato tuber continually develops both morphologically and physiologically. The physiological age of a tuber refers, primarily, to the process of sprout development. It depends on the chronological age of the tuber as well as the environmental conditions.

During its physiological development, the potato tuber passes through the stages of dormancy, apical dominance, multiple sprouting, and senility. During this development, it changes from being physiologically young into being physiologically old.

The physiological age of tubers can be managed by growing and storage conditions. At harvest, tubers produced in a hot climate, in light structured soil, under low soil moisture and low nitrogen fertility conditions are physiologically older than those produced in a cool climate, in heavy soil with soil moisture and high nitrogen fertility.

A crop grown from physiologically young seed tubers has a longer growing period and the total yield is higher than one grown from physiologically old seed tubers. Plants from physiologically old seed tubers develop their yield potential quickly.

[TIB 20: Physiological Development of Potato Seed Tubers. TOP diagram page 6]



1. Dormancy

Dormancy is characterized by no sprout growth. The tuber can remain dormant for several months, and no measurable sprout growth occurs even when conditions are ideal (15^0-20^0C and relative humidity about 90%).

The total dormant period is from tuber initiation until sprouting, but this is very difficult to determine. Post-harvest dormancy, i.e., from harvest to sprouting, is commonly used for practical purposes.

Factors affecting the length of dormancy are:

- variety
- previous growing season
- storage temperature
- tuber injury
- degree od tuber maturity at harvest

Variety. Dormancy may last for less than one month to several months depending on the variety. The length of the dormancy period is not related to the length of the growing period of the variety.

Growing conditions. The conditions under which the tubers are produced influence the length of the dormancy. For example, high temperatures, low soil moisture and low soil fertility during tuber growth (bulking) accelerate physiological development and reduce the dormant period.

Storage temperature. High storage temperatures accelerate the physiological ageing processes within the tuber, thus reducing the dormant period. In some varieties, a fluctuating temperature or a "cold shock" (below 10^0C) for 2-4 weeks is more effective in shortening the dormancy period.

Tuber injury. Injuries caused by harvest and handling procedures, or by pests and diseases, reduce the dormant period. Cutting seed tubers also results in earlier sprouting.

Tuber maturity. Immature tubers have a longer post-harvest dormancy period than tubers harvested at maturity.

2. Apical dominance

At the end of the dormant period, buds in the eyes begin to grow and form sprouts. Frequently, the apical eye begins to sprout first, marking the beginning of apical dominance. The duration of this stage in the physiological cycle differs considerably among varieties. Planting seed with apical dominance often

results in plants with single stems and this leads to reduced yields.

Apical dominance can be influenced by:

- storage management
- desprouting

Storage management. To promote sprout number, maintain a low temperature until apical dominance is over and then increase the temperature. To limit sprout number, maintain a high storage temperature (15^0-20^0C).

Desprouting. Removing the apical sprout induces the formation of multiple sprouts, thus contributing to a uniformly sprouted tuber that produces several stems. Apical sprout should be removed when they are still young. Desprouting when the sprouts are old may cause damage, dehydration and poor resprouting.

3. Multiple sprouting

After the apical dominance stage, additional sprouts develop and the multiple sprouting stage begins. Depending on the variety, this stage may last for several months, especially when the storage temperature is low. Diffused light helps to prolong the multiple sprouting stage and keep sprouts green, short and strong. This is the optimum stage to plant seed tubers. Tubers in this stage give rise to plants with many stems.

4. Senility

Senility is characterized by several symptoms:

- excessive branching of the sprouts
- production of long, weak sprouts
- production of small tubers directly on the sprouts

THE EFFECT OF STEM DENSITY ON POTATO PRODUCTION

1. Definition

The density of a potato crop is traditionally expressed as the number of plants per unit area. However, a potato plant commonly consists of more than one stem. Each stem forms its own roots, stolons and tubers, and behaves like an independent plant. Consequently, stem density is made up of two components:

plant density x number of stems per plant.

Stem density describes the density of the potato crop better than plant density.

Stem density is commonly defined as:

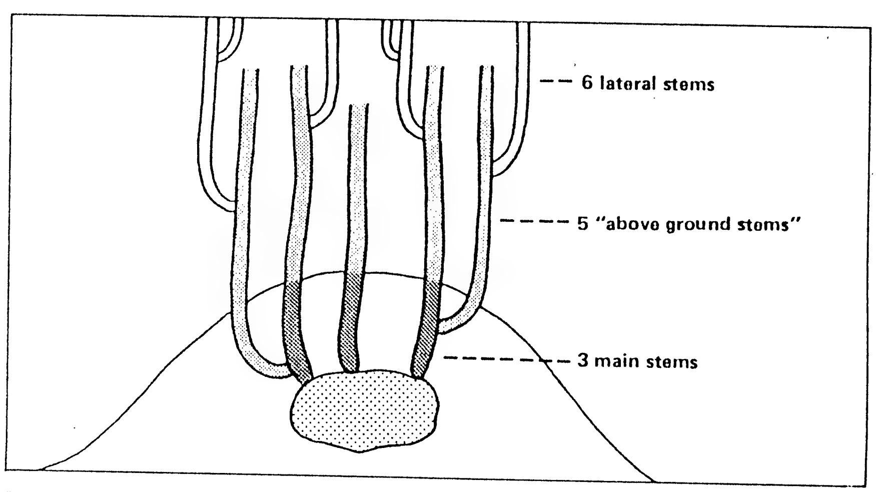
main stems per square meter,

but lateral stems produced in the soil also form roots, stolons and tubers. Therefore, stem density is better defined as:

above ground stems per square meter.

Good ridging is important to ensure that lateral stems formed near the mother tuber are well covered with soil to promote root and stolon formation.

[TIB 1: Effect of Stem Density on Potato Production. Bottom diagram page 7]



Main stems together with lateral stems branching from main stems below the soil surface are referred to as *above-ground stems*. A potato plant may consist of 3 main stems, 5 productive above-ground stems, plus 6 less productive lateral stems.

2. Effects of stem density

Stem density influences:

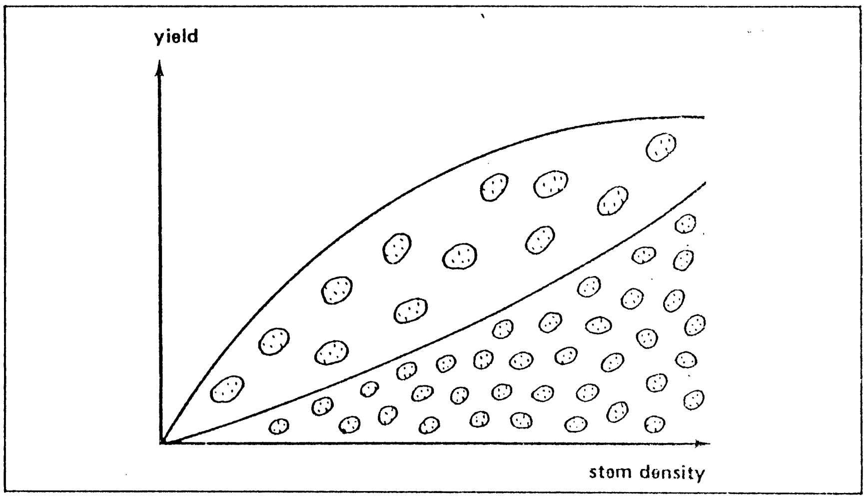
- number of tubers
- size of tubers
- multiplication rate

The number and size of tubers influences yield.

Number of tubers. The number of tubers produced depends on the competition among stems for growth factors such as nutrients, water,and light. At lower stem densities competition is less, and this results in a greater number of tubers per stem, but also a smaller number of tubers per unit area. When stem densities increase, the number of tubers per stem decreases, but the number of tubers per unit area increases.

Size of tubers. Growth factors affect tuber size, which is limited when competition among stems is high. At higher stem densities, the tubers produced remain smaller than at lower stem densities.

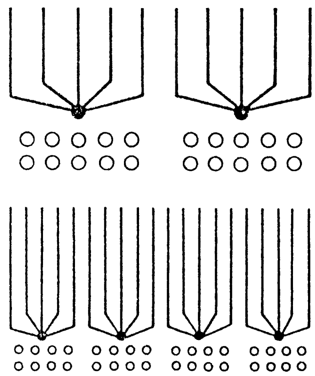
[TIB 1: Effect of Stem Density on Potato Production: Top diagram page 9]



A high stem density increases yield up to a certain level, but reduces average tuber size (higher proportion of small tubers).

Multiplication rate. The multiplication rate is the number of tubers produce from one seed tuber. When stem density increases, fewer tubers are produced; the multiplication rate is reduced.

[TIB 1: Effect of Stem Density on Potato Production. Bottom diagram page 9]



stem number	10	
yield	2.0	kg
tuber number	20	
tuber weight	100	g/tuber
mult. rate	10	

stem number	20	
yield	2.8	kg
tuber number	32	
tuber weight	88	g/tuber
mult. rate	8	

Example: Doubling stem density does not necessarily result in doubling yield. Tuber number increases more than yield, resulting in smaller tuber size. When stem density increases, fewer tubers are produced from one seed tuber; the multiplication rate is reduced.

3. Calculating stem density

Determination of stem density is more accurate at harvest when it is easier to separate the main stems from lateral stems. However, determination of stem density is more practical in the growing crop.

To determine stem density, count the number of above-ground stems per 10 meters of row at several randomly selected places in the field. Then calculate the stem number per square meter.

$$\text{Stem density} = \frac{\text{total stem number}}{\text{total row length} \times \text{row spacing}}$$

Example:

total number of stems at four randomly selected places = 135 + 140 + 160 + 165 = 600 stems

total row length = 4 x 10 meters = 40 m

distance between rows = 0.75 m

$$\text{stem density} = \frac{600 \text{ stems}}{40 \text{ m} \times 0.75 \text{ m}} = 20 \text{ stems/m}^2$$

4. Factors determining stem density

Stem density is determined by the number of main stems that emerge and survive.

The number of main stems depends on:

- seedbed conditions: for good emergence, the soil should be moist and without clods. A dry and cloddy seedbed lowers stem density.

- Planting method: damage to sprouts reduces the number of stems, and often lead to non-uniform emergence.

- Number of sprouts planted.

The number of sprouts planted depend on:

- Number of tubers planted

- Number of sprouts per tuber.

The number of sprouts per tuber depends on:

- Seed tuber size: larger tubers have more sprouts.

- Variety: some varieties develop more sprouts than others.

- Seed tuber treatment: this includes storage, desprouting, cutting, and pre-sprouting. Storage conditions that favor apical dominance limit the numbers of sprouts. Desprouting and cutting of vigorous seed tubers often increases the number of sprouts. Pre-sprouting in diffused light allows sprouts to become well developed and firm, and thereby reduces sprout damage during planting.

- Physiological age: physiologically old tubers develop more sprouts than physiologically young tubers. If tubers are too old, sprouts become too weak for successful emergence.

4. Recommended stem density

The crop environment plays an important part in determining what should be the recommended stem density.

Poor growing conditions caused by low light intensity, low soil fertility, low soil moisture, and poor soil structure cannot support as many stems as good growing conditions. To produce

acceptable tuber size, stem density needs to be lower than under good growing conditions. High stem density under poor growing conditions may only decrease tuber size rather than increase yield.

In Europe, for example, 20-25 stems per square meter are recommended for consumer potato crops, and at least 30 stems per square meter for seed crops.

made up of field staff, and machinery and survey personnel. The course schedule covered all aspects of potato production, with emphasis placed on those areas that appear to be constraints to crop improvement and increased productivity in Afghanistan. About one-third of the extensionists were from provinces that have important potato-growing areas and they will be working directly with farmers to improve yield levels. Their two main activities will be the improvement of seed stocks and the testing of variety Diamant as a possible replacement for the local varieties. Other extension agents were familiar with the crop and, although the group was large, there was good interaction.

2.1.2 Most of the translation was done by Abdullah Naik, but Dr Nabi Aslamy, Qasim Yusufi, Anwar Malham and Syed Habib also assisted.

2.1.3 Course Program

February 9	am	Introduction Potato morphology Planting potatoes Seed tuber physiology
	pm	Crop physiology
February 10	am	Cutting seed tubers Fertilizer application
	pm	Water management
February 11	am	Pests and diseases
	pm	Harvesting and handling Storage
February 12	am	Storage Seed production: improving farmers' seed.
	pm	Improving farmers' seed Roguing
February 13	am	On-farm demonstration trials of new varieties

FERTILIZER REQUIREMENTS FOR POTATO PRODUCTION

Potato growth depends on the supply of plant nutrients, such as nitrogen, phosphorus and potassium, each of which has a specific function. Lack of nutrients results in retarded growth processes and reduced yield.

A potato crop removes nutrients from the soil and replacement is necessary to maintain soil fertility. A crop yielding 4 t/jerib removes approximately 5-10 kg N, 2-8 kg P_2O_5, and 7-15 kg K from the soil for every tonne produced. As only the tubers are harvested from the field, a part of this quantity of minerals remains behind. Fertilizer application to the potato crop in Afghanistan should be within the following limits: 50-75 kg DAP, 50-65 kg urea and 40-50 kg potassium sulphate per jerib.

Fertilizer increases yield. With increased application, yield increase becomes steadily smaller until cost of inputs exceeds yield benefit. Efficient use of fertilizer both meets the land requirements and avoids excessive application.

Fertilizer requirements for a crop under specific conditions are best identified through soil analysis. In most Third World countries this service is not available, and, even when available, resource-poor farmers are not able to afford it. In many cases, farmers have to apply quantities that are available or that they can afford, even though they realize that more fertilizer is needed to optimize yield.

Fertilizers are expensive and may not be easily available, so knowledge about the actions of the nutrients within the plants and in the soil helps the farmer use fertilizers more efficiently.

Nitrogen. In general, nitrogen greatly increases yield. It stimulates haulm growth and so the production potential of the crop. The nitrogen requirement depends on climatic conditions, soil type, soil fertility, the preceding crop, variety (whether long or short growing season), and management practices (especially irrigation).

Depending on all these factors, the optimal dose normally varies from 20-40 kg N per jerib.

Nitrogen is supplied by diammonium phosphate (DAP) and urea. Because nitrogen is easily leached by rain or irrigation, approximately half the nitrogen should be applied at planting time in the form of DAP and urea (approximately 12-16 kg). The remainder of the urea should be applied to the side of the ridges at earthing-up.

Phosphorus. Phosphorus is an essential element in plant compounds that are involved in metabolic processes within the plant. It is especially important for root growth.

Soils with high organic matter content supply sufficient amounts of phosphorus, and virgin soils have sufficient to support subsistence level crops. Soils also contain inorganic forms, but these are not always available to plants, e.g., in volcanic soils. The potato plant uses phosphorus available in soil solution and is supplied in the form of DAP.

Potassium. Potassium acts in carbohydrate formation and the transformation and movement of starch from potato leaves to tubers. It is also important in controlling stomatal movement and the water status of the plant. It is the most abundant element in the plant. Potassium does not always affect yield but it has relatively more influence on the quality of the crop, dry matter content, tuber damage and storage quality.

Potash should be applied at planting. It is thought that soils in Afghanistan are rich in potash and farmers do not normally apply any to their crops. There is lack of evidence of crop response to potash in Afghanistan.

Methods of application. Fertilizers can be:

- broadcast,
- applied in bands, or
- placed near the seed tuber.

Fertilizer can be broadcast in the field after the furrows have been made for planting. Broadcasting the fertilizer is considered to be a drawback in areas where phosphorus and potassium become fixed quickly when mixed with the soil and are unavailable to plants. In areas where high fertilizer rates are applied, soil fertility is high, and no fixation takes place, broadcasting fertilizer is a good practice.

If the levels of soil fertility and fertilizer application are low, placement of fertilizers is advantageous. Placement of fertilizer either mixed in the soil beneath the seed tuber or between the seed tubers in the row puts the nutrients close to the root system. This is highly advantageous but is time-consuming. Most farmers apply the fertilizer in a band in the base of the furrow. With this method the fertilizer must be mixed with the soil before the seed tubers are placed in the furrow. The seed tubers should not be allowed to come into direct contact with fertilizer.

WATER SUPPLY FOR POTATO CULTIVATION

1. Importance of water

A crop in full growth with a closed canopy (all the ground covered by green foliage) can transpire 2-10 mm water per day. That is equivalent to 20,000-100,000 liters per hectare per day, or about 1/2 to 2 1/2 liters per plant per day. At a plant population of 40,000-50,000 plants per hectare, this corresponds to 100 to 200 liters per plant per season. More than 95% of the water that is taken up by the roots is lost to the atmosphere by transpiration, only a very small part being used for growth.

Correct water management provides sufficient water for potato growth and avoids excessive loss or waste of water. Compared to many other crops, the potato plant is sensitive to both lack and excess of water:

- Potato's relatively shallow root system limits the so-called effective root zone to 50-80 m soil depth.

- The root system is weak and cannot penetrate compacted soil. This reduces the effective root zone even more.

- Root-penetration may be restricted when the pH of the different layers in the soil profile vary.

- The suction power of potato roots is relatively low. Additionally, efficiency of roots may be affected by diseases and pests.

- The stomata of potato leaves close quickly upon lack of humidity. Stomatal closure leads to reduced transpiration and photosynthesis, heating of the leaves, and subsequent reduced yield.

Lack of water. Lack of water is the most common stress. The potato does not compensate for drought periods by prolonged growth. Even a short period of drought affects the yield, especially after tuber initiation.

Dry soil causes reduction in the number of stems. In a dry and cloddy soil only sprouts that have access to water develop.

Drought influences yield directly by restricting transpiration and photosynthesis. Indirectly it leads to reduced evaporation from the soil and leaves, thereby increasing soil and plant temperature. High temperature is unfavorable to tuber initiation. Drought also contributes to tuber defects, and dry

soils form clods that make soil and crop management difficult and cause tuber damage at harvest.

Excess of water. Excess water may be caused by heavy rainfall, heavy irrigation, or inefficient drainage. Waterlogging of parts of irrigated fields can be the result of poor land levelling.

Too much water prevents oxygen from reaching the underground parts of the potato plant, and this results in poor root development and rotting of the newly formed tubers. Seed tubers (and cut seed pieces) are especially susceptible to tuber rot.

High moisture favors development of late blight (Phytophthora infestans). Excess water results in waste due to percolation and surface run-off. It also increases erosion.

Variation of soil moisture. Excessive variation in soil moisture affects tuber quality.

Water after a prolonged drought may cause secondary growth: tubers form bottle neck-like or knobbly shapes and may crack. New haulm growth may be at the expense of tuber yield. A restarting of tuberization results in formation of many small tubers.

2. Water requirement during the growing season

Period between planting and emergence

The soil around the seed tuber should be moist but not wet. If the farmer has access to water at any time, irrigation should be done with great care and only a small amount of water applied each time.

Under high temperature conditions it is extremely important that at and after planting the soil in the ridge is kept moist in order to decrease the temperature.

Insufficient water supply at this period may cause:

- delay in and an uneven emergence or even total failure, and

- a reduced number of stems per plant.

Over irrigation may cause seed tuber decay and thus blank spaces in the rows.

Period between emergence and tuber initiation

Water supply at tuber initiation (swelling of the stolon tips) influences common scab (Streptomyces scabies) attack on the tubers and the number of marketable tubers per plant at harvest. Moist soil around the newly formed tubers for a period of about three weeks can protect the tubers from scab attack. If common

scab is a problem, a few light irrigations during this period is recommended.

Period after tuber initiation (bulking period)

During bulking the crop needs a lot of water. Insufficient water results in reduced yield.

There should always be an even distribution of water to ensure regular growth of the tubers. Uneven distribution of water may cause second growth or misshapen tubers. Thus water supply not only greatly affects tuber yield but also tuber quality. Water is therefore one of the key factors in potato production.

Period immediately before harvest

If the crop is grown under irrigation, water should not be applied during the last 7-10 days before harvest. The timing of the final irrigation will depend on the temperature and the stage of maturity (senescence) of the crop.

The soil must not be allowed to dry out completely, especially when the temperature is high, because harvesting will be difficult and tubers will be damaged.

Tubers near the surface in dry soil that is exposed to the sun will develop physiological defects such as internal brown spot (net necrosis).

3. Furrow irrigation

Furrow irrigation is the oldest system and still applied in many parts of the world.

The advantages of furrow irrigation are:

- low investment, and
- no wetting of the foliage (favorable in preventing foliage diseases and when using saline water).

The disadvantages are:

- high labour demand,
- low application efficiency (run-off, percolation, and inadequate distribution; only 50-70% of the water applied will be used by the crop), and
- obstacle to mechanization.

Furrow distance. The distance between irrigation furrows varies from 60 to 90 cm depending on the soil texture. In sandy soil, water leaks away rapidly and does not reach far; the distance between rows should be smaller than in clay soils. In coarse

sandy soils the distance between furrows should preferably be about 60-65 cm, and in heavier clay soils about 70-80 cm.

Furrow length. Make furrows as long as uniformity of water supply and furrow slope allows. The maximum furrow length will depend on the slope of the furrows, soil type and recommended depth of water in the furrow. Water should not exceed half the ridge height to avoid excess moisture in the tuber region. If only small quantities of water are applied at each irrigation, the length of the furrows will have to be short.

In poorly levelled fields, short furrow irrigation is necessary. This requires more space for auxiliary supply channels and is more labour intensive.

Furrow slope. Serious erosion occurs when furrow slope exceeds 2% (2 m per 100 m row length). In mountainous rainfed areas, intense rains can cause erosion in slopes in excess of 0.3%. When the field surface is uneven, furrows on the contour help prevent erosion and water loss.

Ridge uniformity. Uniform ridges permit an even distribution of water to the potato plants.

POTATO PESTS AND DISEASES

1. PESTS

1.1 Insect control

Insects can cause direct or indirect damage to crops. Indirect damage is caused by the fact that insects (mainly aphids) are vectors of viruses. In ware potato production, insect control concentrates mainly on the prevention of direct damage, while in seed production both direct and indirect damage should be prevented.

Measures to control direct damage include the use of insecticides, although there is growing concern over there use (environmental pollution, build up of resistance, danger to humans, etc.). In some cases a certain level of attack has to be accepted, especially foliage damage, when insecticidal control is not economic.

Depending on the pest, chemical control can be through:

- foliar application of insecticides
- soil application of insecticides to the growing crop
- application of chemical to the soil at emergence
- chemical applied and mixed with the soil before planting
- treatment of tubers in store

Cultural practices, such as crop rotation, proper soil tillage, soil drainage, and a good ridging system, are very important in reducing pest infestation.

Most pests can be controlled at the time they appear, but measures to control white grubs and wire worms have to be carried out in advance whenever an attack may be expected. For some insect pests, such as potato tubermoth, more than one control method has to be applied.

1.2 Cutworms (*Agrostis* spp. and other Noctuids)

These nocturnally active moths are distributed worldwide. Damage is caused by the larvae. Most cutworms are about 50 mm long and curl their body into a tight ball upon disturbance. The **black cutworm** consumes or "cuts" stems near the soil surface. The **armyworm** consumes foliage, and **subterranean cutworms** cause damage by gnawing cavities into tubers, especially those near the soil surface.

A potato crop following after grasses or cereals is likely to suffer from cutworm attack. Good ridging reduces attack on tubers and insecticides can also be mixed into the soil before planting. If cutworms become a problem after planting the soil surface can be dusted with insecticide.

Most cutworms can be controlled with baits prepared by mixing proprietary insecticides with wheat bran, molasses and water. The baits are distributed around the plant stem bases shortly before dusk.

1.3 Aphids

The most important aphid infesting the potato crop is the green peach aphid, *Myzus persicae.* Aphids do more damage by transmitting virus diseases than by feeding on the plants. *Myzus persicae* is also the most important and efficient vector of potato leafroll virus and potato virus Y (PVY).

Aphids transmit viruses in two ways:

- non-persistent transmission
- persistent transmission

Non-persistent transmission. Aphids may acquire viruses during a brief period of probing or feeding on the epidermal tissues of infected plants. It may take only a few seconds for the mouth parts to become contaminated, and then aphids can transmit viruses immediately to other plants. Aphids remain infective for a relatively short period, usually not more than two hours, and viruses can only be carried over short distances. The group of potato viruses that are transmitted non-persistently include PVY, PVA and PVM. Within a field, insecticides may slightly reduce virus transmission, but they cannot prevent it; neither can they control infections from outside the field.

Persistent transmission. Viruses that are persistently transmitted are located in the phloem tissue of the plant, and this group is represented by potato leafroll virus (PLRV). The aphid must feed on the phloem for at least 20-30 minutes to acquire the virus. The virus enters the aphid's body, and after a latent period of several hours, the aphid is able to transmit the virus. The aphid remains infective for the remainder of its life and can therefore carry the virus over long distances. Insecticides can greatly reduce PLRV spread within a field, but they cannot control infections from outside by migrating aphids.

2. DISEASES

2.1 Integrated control

There are specific methods of control for each disease, but in commercial potato production several diseases are usually controlled at the same time. The methods used to control some of the major diseases often include the control of minor diseases that would otherwise not merit separate control measures. It is important to know each disease and its particular control measure so that, in practice, the total control system can be adjusted according to any particular circumstance.

Diseases are only controlled to a certain degree and it would be impossible or, if possible, too expensive to effect complete control. The degree of infection that can be tolerated depends on the threat posed, the losses (quantitative and qualitative) caused, and the purpose of the crop (consumption or seed production).

2.2 Reduction of crop losses

Diseases may cause crop losses due to:

- seed decay or attack on the sprouts leading to a poor stand
- attack on the leaves by fungal diseases causing a reduction in the growing period with consequent low yields
- reduced haulm growth and a decreased assimilation caused by virus diseases
- wilting plants due to bacterial or fungal infection also resulting in a reduction in the growing period with consequent low yields
- lesions in the tubers
- tuber rotting during the growing season or during storage
- attack on the root system
- skin blemishes caused by fungal diseases resulting in lower prices
- misshapen and smaller tubers.

Besides losses in the current crop, the consequences of diseases carried over by the tubers to the next crop should also be taken into consideration.

2.3 General methods of control

Most control methods are not sufficient on their own to provide effective control, and a combination of various methods will have to be adopted.

The methods available are:

- cultural practices (1) soil tillage, planting and ridging procedures, (2) seed preparation, (3) water supply, drainage, irrigation, (4) roguing and haulm destruction, and (5) harvesting, handling and storage methods
- use of clean seed
- tuber disinfection
- foliar application of fungicides
- rotation
- isolation.

Cultural practices

Soil tillage helps control weeds and groundkeepers (which can carry over of diseases to the next crop), and promotes rapid emergence, important for reducing losses due to seed decay and attack by pathogens such as Rhizoctonia.

Seed preparation. Presprouting assists in rapid emergence and lessens attack from Rhizoctonia. Cutting seed tubers, the normal practice in Afghanistan, increases the risk of spreading diseases such as contact-transmitted virus diseases (e.g. PVX) and bacterial wilt during the cutting process. The cut surface allows easy entry for soil pathogens that cause seed piece decay.

Water supply. Many pathogens can enter the tuber if the soil is very wet, as the lenticels are open. Over-irrigation at tuber initiation increases the chances of common scab disease. Very wet soils after planting increase the number of seed pieces that decay.

Roguing, or removing plants from the field, is important in the control of virus disease spread in crops grown for seed production and to ensure a low percentage of infected tubers at harvest.

Haulm destruction immediately before harvest greatly assists in lessening the chances of fungal and bacterial diseases being spread from the foliage to the surface of tubers. Tubers so contaminated can eventually rot if storage conditions are ideal for pathogen growth.

Harvest, handling and storage. Tubers that are damaged due to bad harvesting techniques and poor handling are at greater risk

pm Working with farmers
The history of potato improvement in Pakistan (Mahfooz Ali Shah)

2.1.4 A visit was arranged to meet potato farmers in Pabbi, a district on the outskirts of Peshawar on the road to Islamabad, on Wednesday afternoon, February 12 but had to be canceled because of rain.

2.1.5 The lecture by Mahfooz Ali Shah, Director of Outreach at the Agricultural University, and for many year during the 1970s and early 1980s Coordinator (Potato) at the Pakistan Agricultural Research Council, Islamabad, was to give the DAI extension agents an insight into how Pakistan has been able to improve its potato crop through research and development activities.

2.1.6 During the course, particular attention was given to practical aspects of production with many examples drawn from personal experience in southwest Asia. Textbook theory was avoided. Time was taken to go over details of varietal testing and seed improvement at farm-level, as these two projects will form the greater majority of the extension work on the crop.

2.1.7 At the end of the winter training course an evaluation will be carried out. The questions and answers for the potato component are given in Annex I.

2.2 <u>Training materials</u>

2.2.1 Training materials based on the lectures were prepared for distribution and for translation into Farsi. See Annex II.

2.2.2 The following slide sets and the accompanying Technical Information Bulletins, purchased on behalf of DAI from the International Potato Center, Lima, Peru were used during the course and have been left with ADT for future training programs:

Systemic Botany and Morphology of the Potato
Planting Potatoes
Physiological Development of Potato Seed Tubers
Effect of Stem Density on Potato Production
Roguing Potatoes
Potato Leafroll Virus
Transmission of Potato Viruses by Aphids
Soft Rot and Blackleg of Potato
Major Potato Diseases, Nematodes, and Insects

2.4 Late blight (*Phytophthora infestans*)

This is the most serious fungal disease of potato and is found almost everywhere the crop is grown. The disease, if not controlled in the early part of the season, can completely wipe out a crop. Later infection can greatly reduce yield. The disease can enter the crop from:

- an infected tuber that has been planted. These usually rot but sometimes sprouts emerge and carry the disease from the tuber.

- infected tubers found in piles of potatoes discarded the previous season and left on the farm.

- neighboring potato fields.

- other host plants, e.g., tomato.

The earliest symptoms are often found on the lower leaves. They consist of small pale spots that turn into brown or black lesions. The lesions expand until all the leaf is necrotic. Spores, which are responsible for spread of the disease, are found on the underside of the leaf as a white mildew surrounding the lesions. Spores are formed and spread when weather conditions are favorable (dull, humid, rain, wind, and temperatures between 15-20^{0}C). Under ideal conditions, the disease can spread from a few infected plants to all the plants in a field. Spread can be checked if the crop is sprayed when the first lesions are observed. There are no varieties that are completely resistant, but some varieties show high levels of tolerance to infection. Breeding program are developing material to select varieties that will either not require spraying or only one or two applications of fungicide.

2.5 Early blight (*Alternaria solani*)

This can be an important disease in many of the warmer potato-growing areas. The disease occurs on foliage and sometimes on tubers. If tubers are heavily infected, losses in storage can be substantial.

More or less circular, dark-brown lesions first appear on the lower, older leaves. With heavy infections the leaves turn chlorotic, dry and die, and lead to defoliation. The fungus survives from season to season on plant debris, and this is the main source of primary infection in a crop. The spores are spread by wind. Foliar infection (spread from plant to plant) is favored by warm (about 25^{0}C) and wet conditions. Rainfall is not required if heavy dew is frequent.

Infected plant debris (dead haulms) should be removed from the field after harvest. The fungus cannot survive on plant debris for several years in the soil, therefore crop rotation may help to reduce inoculum in a field. Early blight can be effectively

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controlled by fungicide sprays (the same fungicides as are used against late blight) provided that application is timed to coincide with the secondary spread of spores from plant to plant. This occurs after the disease has become established on the lower leaves, following infection from plant debris on the soil surface.

POTATO HARVESTING AND HANDLING

The time of harvest is usually dictated by the maturity of the crop, although a farmer may wish to harvest early in order to get a higher price for his produce in the market. Apart from yield, the quality of an immature crop is influenced by early harvesting. The skin of an immature tuber is weaker and more susceptible to damage, thereby increasing the likelihood of infection by fungal and bacterial pathogens.

1. Haulm destruction

It is common to cut, pull out, burn or destroy haulms before harvesting. In many countries this is done with chemicals, but cutting the haulms by hand is just as effective although costly in labour. The haulm is destroyed to facilitate harvest and to allow the skin of the tuber to harden.

Green haulms should be cut or the haulms should have died back at least 10 days before harvest. If the crop is very immature, more than 10 days are required to allow the skins to harden. If the weather is hot and dry at harvest time, the soil dries out and heats up very quickly once the haulms are dead or removed. The soil exposed to the direct sun should not be allowed to dry out nor the soil temperature exceed 30^{0}C. Under these conditions tubers that are near the surface of the soil will develop a physiological condition known as internal heat necrosis and rot.

Haulm destruction, especially when the potatoes are not yet mature, greatly affects the release of the tubers from the vines at harvest. As tubers can be attacked by micro-organisms such as Rhizoctonia solani and by pests during this period, the time interval between haulm destruction and harvesting should not be too long.

2. Harvesting operations

Harvesting potatoes includes the following operations:

- digging
- collecting the tubers in the field
- grading
- bagging
- transport to the farmhouse, store or market

The aim of each harvesting operation is to take the tubers from the soil to the store or market as cheaply as possible, keeping losses in quality to a minimum.

The harvesting system used depends on:

- the economic situation (labour costs, market price)
- the quantity of potatoes to be harvested and the time available
- the size, shape and situation of the potato field
- the soil and weather conditions
- the use to be made of the potatoes (immediate consumption, storage).

Digging

The ideal conditions for digging the crop is on a dry day when the soil is dry on the surface but still moist around the tubers. Digging should be done, preferably, early in the morning and, during hot sunny weather, discontinued when the sun begins to make the tubers warm.

When digging with hand implements, great care should be taken to ensure that tubers, especially those at the side and in the base of the ridges, are not damaged. Poor digging can reduce the quality of the produce and the farmer's income. It is often responsible for losses in storage caused by rotting; cut and damaged tubers allow easy access for fungi and soft rotting bacteria.

Harvesting should be discontinued before mid-day if the temperature is high and the tubers exposed on the surface of the soil are becoming hot.

Collecting the tubers in the field

The tubers have to be collected from the rows and brought to a number of places in the field, ready for grading and bagging. Again care must be taken in handling the tubers during this operation.

If the weather is sunny, the pile of tubers should be covered with haulms to keep them cool, or placed under trees or in some other shaded area.

Grading

When the potatoes are to be sold directly in the market, grading for size may not have to be done, but cut and damaged tubers should be excluded so that quality is maintained.

When damaged tubers are bagged with sound tubers, and the bags are transported and stored before the produce is sold in the

wholesale or retail market, rotting may occur and result in large losses. If the farmer still owns the potatoes in storage, he is going to lose money. If the transporter or wholesaler has bought the potatoes at the farm, he is not likely to purchase from the same farmer in the future. Farmers should build up a reputation for quality produce.

The farmer who stores seed tubers for his own use and for sale during the following year must pay particular attention to grading. Whenever possible, seed-size tubers of 30-50 g should be selected, or larger ones that need only be cut into two pieces. All tubers should be sound, with no skin abrasions or cuts, nor any sign of fungal or bacterial infection or nematode infestation. These tubers should be completely free of soil, which can act as a source of infection in storage.

POTATO STORAGE

1. Introduction

If there are only one or two harvests per year, potatoes need to be stored to ensure a regular supply and to obtain higher market prices. To ensure that farmers have tubers of the correct physiological stage for planting, adequate storage methods for seed tubers are essential.

It is important to determine which storage method is the most appropriate. The method used will depend on:

- purpose of the crop (consumption, seed)
- duration of storage
- outside temperature during storage
- quantity of potatoes to be stored
- method of handling

The storage life of a potato depends on:

- storage temperature
- quality of the crop
- variety

Storage life of tubers kept at different temperatures.

	Months in storage		
Temperature (^{0}C)	Consumption (dark)	Seed (dark)	Seed (diffused light)
4	10	10	11
10	5	6	9
15	4	5	8
20	3	4	6

2. Storage losses

Losses are unavoidable and are due to:

- evaporation
- respiration
- sprouting
- infection by fungi and bacteria
- infestation by insects

Storage condition should be such that:

- losses are kept to a minimum
- tubers are brought to and kept at the right physiological stage
- the chemical composition of the tubers is brought to and maintained at the desired quality

2.1 Evaporation losses

The potato tuber consists of 80% water, and the main weight loss during storage is water loss, which reduces quality. Water evaporates through the skin, wounds and sprouts. The ratio of the amount of water loss per unit area of skin, wounds and sprouts is 1:300:100, respectively. Evaporation is relatively high if tubers are damaged or have a weak, injured skin. Sprouting also leads to high evaporation losses.

Ventilation--the circulation of air--is essential to keep the surface of the tubers dry, to remove heat and supply oxygen. Therefore, water losses will always occur, and these are approximately 1.5% of the fresh weight in the first month and 0.5% in subsequent months.

Losses caused by evaporation depend largely on:

- the ventilation rate
- the duration of ventilation
- the relative humidity or vapor pressure deficit of the air used for ventilation.

2.2 Respiration losses

A potato tuber is a living organism and therefore respires. Oxygen, absorbed from the atmosphere, and carbohydrate from the tuber are converted into carbon dioxide, water and heat. The respiration rate and the production of heat depends on the temperature of the tubers. Other factors affecting the respiration rate are:

- maturity of the tubers
- presence of wounds
- oxygen content of the atmosphere.

The heat produced in storage due to respiration should be removed by ventilation. If more heat is produced than is removed, overheating occurs. This is the case when ambient air temperature is relatively high, the respiration of the tubers is high and the ventilation is poor.

To avoid oxygen starvation of the tubers (causing a condition called black heart), the carbon dioxide must be removed and replaced by oxygen. The air surrounding the tubers should be replaced with fresh air from time to time. At least 4-5 cubic meters of fresh air is needed every 24 hours per 1,000 kg of potatoes to supply sufficient oxygen for the respiration process.

2.3 Sprout growth losses

Sprout growth causes excessive losses due to:

- evaporation
- increased respiration
- transfer of carbohydrate from the tuber to the sprouts.

During the first three months when the tubers are dormant, no sprout growth occurs. Temperature has no effect on the length of the dormant period, but it does have an effect on sprout growth. With increasing temperature, sprout growth accelerates. Moisture also stimulates sprout growth. Light reduces the growth of sprouts, and diffused light is very effective when storing seed potatoes.

2.4 Losses caused by fungi, bacteria and insects

Diseases and pests can cause major losses during storage.. Potatoes should be carefully graded before being put in storage in order to remove damaged tubers or any tubers showing signs of fungal or bacterial infections or insect infestation.

Good ventilation that reduces the temperature and removes free water from the surface of the tubers will help to reduce losses caused by fungi and bacteria. The important organisms causing soft rots are:

- Erwinia spp.
- Pseudomonas solanacearum
- Corynebacterium sepedonicum
- Pythium spp.
- Phytophthora infestans
- Phytophthora erythroseptica

Organism causing dry rots (Fusarium spp., Macrophomina sp., and Phoma sp.) may spread and cause serious losses.

Other fungi that do not cause rots, such as Rhizoctonia solani, but found on the outside of the tuber skin, may spread in storage and reduce tuber quality.

2.5 Physiological stage

Potatoes for consumption should have little or no sprout growth at the end of the storage period. The storage temperature will depend on the length of the storage period required.

Seed potatoes should be stored so that the tubers sprout and emerge quickly immediately after planting. As with consumption potatoes, the storage temperature will determine the length of time that the tubers can be stored. Diffused light will prolong the storage period of seed potatoes.

3. Factors affecting the keeping quality of tubers

There are only a limited number of factors that enhance the keeping quality of stored potatoes. These are:

- good tuber quality and skin
- proper ventilation
- low temperature
- low moisture and humidity
- light (seed tubers only)
- chemicals (sprout depressants).

3.1 Tuber and skin quality

Storage will only be successful if the tubers entering the store are sound and have a good skin which is not damaged. Cultural practices and disease and pest control during the growing season influence the quality of the skin. Immature tubers are difficult to store as they have low dry matter content and weak skins.

Before putting potatoes into permanent storage, it is advisable to put the tubers into temporary storage for one or two weeks to allow the skins to cure properly and for disease symptoms to

3. Cultural Practices

3.1 The highland crop, in such provinces as Kabul, Bamiyan, Ghazni, Logar, Paktika, and Wardak is mostly grown in a three course rotation with wheat and clover. The clover is plowed in during land preparation in April, and the crop is planted from the end of April to the middle of May and harvested in September/October. Winter wheat is then planted and followed by clover after harvest mid-July to the end of August.

3.2 In the low elevation potato-growing areas in Baghlan, Nangarhar, and Kandahar where there are two growing seasons, the potato crop is planted in February/March and harvested during May and June.

3.3 In the major production provinces--Bamiyan, Kabul, Wardak, Ghazni, Logar, Paktika, and Baghlan--farmers who grew potatoes as a cash crop pre-war, up to the late 1970s, applied DAP and urea fertilizers as well as using farm yard manure. Farmers, who grew only a small area of the crop for their own use, did not apply artificial fertilizer. At present, the lack of availability of fertilizer is a main factor for low yields. If fertilizers were available in the market, farmers would use apply then to the crop because they already know the financial benefits.

3.4 Changing cultural practices is the most difficult aspect of improving crop yields and has to approached on a step by step basis. Farmers will not adopt a "package of practices", but are likely to change only one, or two at the most, production techniques. Therefore, it is recommended to target the issue of stem density that is greatly influenced by size of the seed tuber or cut seed piece and its physiological condition at planting. The size of the planting material itself influences the number of eyes, and therefore the number of stems. The physiological condition of the tuber also determines the rapidity of emergence. A stem density in the region of 20 stems per m^2 is desirable under good soil fertility. The extension agents should pay attention to this particular aspect and assist farmers in ensuring that this level is achieved. It should be noted that soil of poor fertility cannot sustain crops of high stem density because of the competition for limited amounts of nutrients.

3.5 It is recommended that a poster is designed to illustrate the value of planting 40-50 g tubers or cut seed pieces with sufficient eyes to get the stem density and crop cover needed for yield improvement.

become more visible. This improves the selection process.

If potatoes are to be kept in cold storage at 4^0C, they should be kept at 15^0C for the first few weeks to allow the skins to cure, before the temperature is lowered.

3.2 Ventilation

Ventilation is needed to remove heat, water and carbon dioxide, and to supply oxygen. Natural or forced draught ventilation can be used to ensure that the air passes through the heaps of potatoes (bulk storage) or bags of potatoes.

Natural ventilation of pit stores that are completely closed is not possible, and overheating occurs. This results in heavy losses. Pits are sometimes fitted with chimneys to allow the hot air to escape, but air movement is restricted. If the pit design can allow for an opening to permit air to enter at the base of the pit (as used by farmers in Bamiyan), then greater cooling of the tubers can be obtained.

3.3 Temperature

Temperature largely determines how long potatoes can be stored. Temperature is determined by climatic conditions, method of storage and storage design.

Tubers left in the soil will have the same temperature as the soil. A system of "delayed harvest" may be applied up until the end of the dormancy period in regions with moderate temperature and well drained soils.

The rise in temperature in storage pits in the ground results in over-heating, excessive sprouting and substantial losses due to fungal and bacterial soft rots.

3.4 Moisture and humidity

During storage, potatoes should be kept dry, but excessive loss of water should be avoided. If harvested in the wet, potatoes should be dried before storage, or by initial continuous ventilation if placed in a ventilated store. Free moisture on the surface of stored tubers provides ideal conditions for the spread of diseases.

3.5 Light

Light is a good alternative to low temperatures when storing seed potatoes. When keeping potatoes in diffused light, their storage life can be prolonged.

SEED PRODUCTION:
ON-FARM IMPROVEMENT OF FARMERS' SEED

The sources of seed tubers for planting are:

- farmer's own seed
- neighboring farmer
- local market
- recognized seed grower
- government seed production scheme

Farmers in Afghanistan are not able to buy certified or improved seed potatoes because there is no seed scheme within the country and there is no importation of seed tubers.

Those farmers who grow potatoes at low elevations are unable to keep tubers from one planting season to the next and therefore must purchase seed tubers in the local market or from another province where the crop is grown at higher elevations and stored from one year to the next. In these highland areas some farmers will have poor crops with a high percentage of virus and other diseases that are transmitted in the tubers. With these types of crops it is very difficult, but not impossible, for farmers to improve the health status of their stocks. When crops contain a reasonable percentage of healthy-looking plants, it is very easy to improve the quality of the seed tubers that farmers save for their next year's crop.

The principle behind the method is one of positive selection, i.e., the selection of healthy-looking plants to provide tubers for the following seed crop. The method is known as the **seed plot technique**.

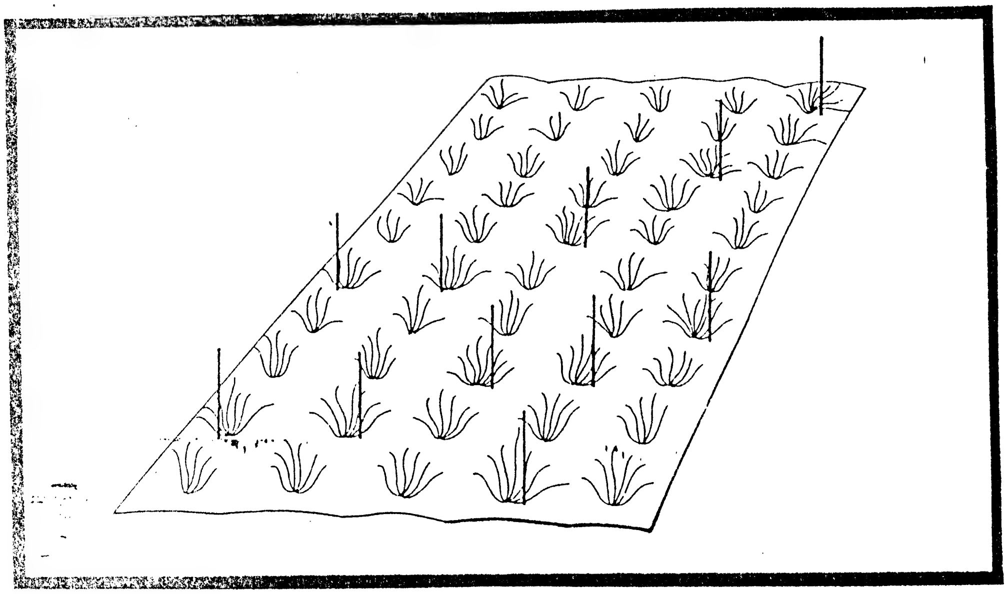
Procedure. The size of the farmer's selection program depends on the number of jeribs that he usually grows. The program includes the following steps:

(a) If the farmer has more than one field of potatoes, he decides on the best field in which to make his selections.

(b) Selection should be made when the plants almost touch each other and can still be recognized as individual plants. If the crop is a mixture of two or more varieties, selection should be made at flowering time when varietal differences are more easily recognizable. Mark the best healthy-looking and most vigorous plants in the field with stakes. Stake all plants needed at the same time. Stake only plants of the same variety to avoid mixtures. Stake more plants than are actually needed to plant the seed plot the following year.

(c) Check the staked plants during the remainder of the growing season and remove stakes from any that develop virus symptoms or look unhealthy (e.g. wilting). Plants with foliar diseases such as early or late blight should still be selected.

[Diagram page 10 of July/August 1991 Report]



Mark the best and most vigorous plants in the field with stakes. (From Bryan,J.E., 1981, On-farm seed improvement by potato seed plot technique. Technical Information Bulletin 7, International Potato Center, Lima, Peru.

(d) Harvest the staked plants and remove the tubers from the field before harvesting the rest of the crop. This will avoid tubers from other plants getting mixed with those from the selected plants. During harvest eliminate plants with poor yields, tuber-borne diseases or deformities.

(e) Store tubers harvested from staked plants separately from other potatoes to avoid mixture and contamination.

(f) Plant the selected tubers the following year in a newly established seed plot, preferably on land not used for potatoes the previous season and, if

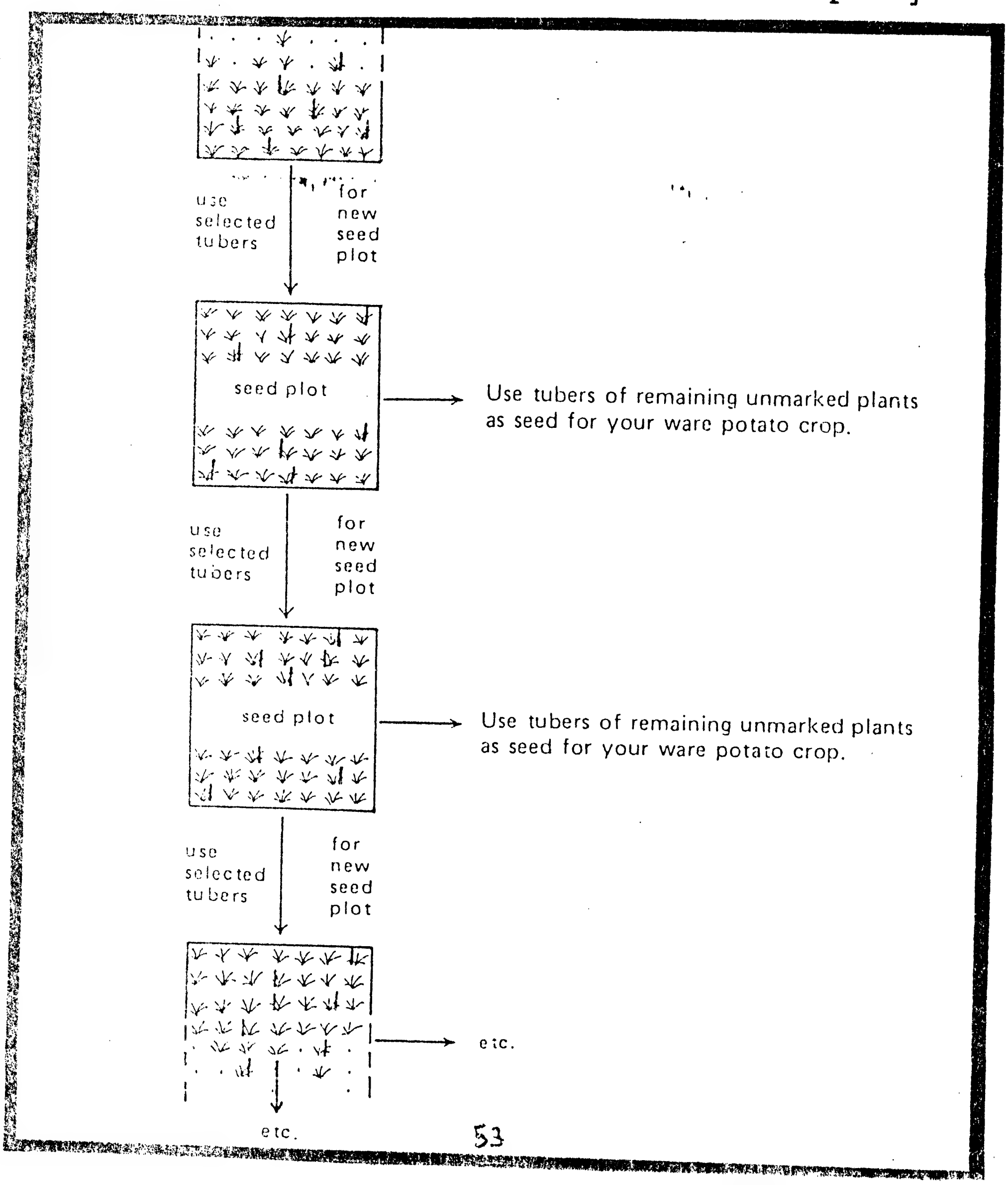
possible, some distance from other potato crops.

(g) Again, as in (b), the best plants in the seed plot are staked.

(h) The selected plants are harvested and stored as in (d) and (e). These tubers are needed to plant the seed plot the following season. Tubers from the remaining unmarked plants are multiplied to provide seed tubers for the farmer's own commercial potato crop during the next year.

(i) The farmer should continue this process to ensure a marked and continuing improvement in the quality of his seed tuber material, in the health standard of his commercial potato crop, and in yields.

[Diagram page 11 of July/August 1991 Report]



Seed plot technique repeated each season.
(From Bryan,J.E., 1981, On-farm seed improvement by potato seed plot technique. Technical Information Bulletin 7, International Potato Center, Lima, Peru.).

Calculation of the number of plants to stake to provide seed for 1 jerib.

A spacing of 65 cm x 25 cm = 61,538 plants/hectare
= 12,308 plants/jerib.

If the farmer gets 20 t/ha (4 t/jerib), average yield per plant is 325 g. A healthy-looking and vigorous plant should give at least 450 g.

If 20% is lost during selection and storage, each plant provides 360 g or 12 seed pieces of 30 g each.

110 staked plants will provide 110 x 12 = 1,320 seed pieces for planting the seed plot in the following year.

110 plants will be staked for the next seed plot leaving 1,320 - 110 = 1,210 plants.

The tubers from these plants will provide 1,210 x 12 = 14,520 seed pieces, sufficient to plant a little more than one jerib.

If the farmer plants seed pieces larger than 30 g, he will have to stake more plants. For example, if seed piece weight is about 40 g, stake about 150 plants. Similarly, if his yields are lower he will have to increase the number of staked plants (e.g., twice the number if the yield is only 10t/ha). In practice, make the seed plot slightly larger than calculated to compensate for plants eliminated at harvest or greater losses during storage. After one or two seasons, a farmer will know how many plants he has to stake so as to provide planting material for his commercial crop.

ROGUING POTATOES

Roguing is a control technique in which infected plants are identified, dug up, removed from the field, and destroyed. By roguing, farmers eliminate plants that produce diseased seed tubers as well as contamination sources within a crop. Roguing can also be used to eliminate "off-types" or plants of other varieties from a crop.

Roguing, also referred to "negative selection", involves selecting undesirable plants to be removed from the field. These plants are selected on the basis of visible symptoms.

Roguing is impractical in fields where most of the plants are infected. In such cases, use "positive selection", a process in which only the best plants are selected and reproduced.

How thoroughly a field is rogued depends on the use of the produced seed. Because of economic reasons, farmers are often reluctant to eliminate plants, even those with serious diseases. Experiments have shown, however, that the remaining healthy plants fill up the empty spaces and compensate of this plant loss by producing higher yields, especially when roguing is carried out early in the growing season.

The types of plants to be rogued fall into the following categories:

- diseased plants
- atypical plants
- volunteer plants

Diseased plants that should be rogued out are those infected with systemic diseases, especially virus and bacterial diseases. The symptoms of the different diseases should be known so that infected plants can be recognized and removed.

Atypical plants include those of other varieties and plants with cytoplasmic and genetic variation. It is important to be able to recognize the varieties that are grown within a country so that varietal purity can be maintained.

Volunteer plants grow from tubers that remain in the ground from the previous season. These plants affect varietal purity and can be a sources of infection and hosts of the first insects that appear in the crop. Volunteer plants usually emerge earlier than the planted variety.

Roguing procedure

Roguing should begin immediately after infected or undesirable plants are detected, usually a few days after emergence. The sooner the infected plants are removed, the less chance there is of disease spreading to healthy plants in the crop. Roguing

should continue during the season as long as it is possible to pass between the rows without touching the foliage.

Roguing consists of four basic steps:

1. Identifying plants to be rogued
2. Digging up plants, including the tubers, stolons and roots
3. Removing the plants from the field
4. Destroying the plants

Identifying plants. Once you are familiar with the growth characteristics of a variety, it is very easy to identify plants that do not appear healthy. Stay at least one row away from the plants that you are checking in order to be able to compare groups of three to five plants.

Digging up plants. Systemic diseases such as those caused by viruses and bacterial infect all the vegetative parts of the plant. Therefore, it is essential to remove all the plant, including the very small tubers, stolons, and even the mother tuber. If not, regrowth may start another source of infection. Use a fork or other digging implement to remove the plant from the soil. Do not pull the plant up by hand as parts may break off and remain in the soil. Sometimes it is necessary to remove the adjacent plants (in the row) to the infected plant, especially with diseases like bacterial wilt where bacteria in the soil can infect neighboring plants through the root system.

Removing plants from the field. To avoid disseminating infective aphids and soil from around the roots of bacterial diseased plants, carefully place the plants in bags. If aphid populations are high, it is advisable to spray the crop before roguing to kill the vectors and reduce virus spread.

Destroying plants. Bury or burn the infected plants.

NOTES ON WORKING WITH FARMERS

Many agricultural scientists, both researchers and extensionists, do not credit small, resource-poor farmers with knowledge about how to grow good crops and attain high yields. Farmers, often with the help of their family, work on their farms to feed and clothe their family and educate their children.

Farmers have to make a profit and are very shrewd economists. Many of the things they do, for example the cultural practices they employ, are based on experience, often gained through many generations of farming the land. The decisions that are made regarding crop husbandry and post-harvest techniques are not based solely on biological findings; consideration must be given to both economic and social factors that impinge on farming practices. The time of planting a crop may be determined by the availability of labour (a social consideration), and the seeding rate and quantity of fertilizer applied may depend on the amount of money available to purchase inputs (an economic consideration). Often, farmers do not follow government recommendations of production practices, not because of their inability to understand and appreciate improved cultural practices that will maximize yields, but because of lack of finance for the purchase of inputs, the financial risks involved or marketing problems.

The first thing an extension worker must do when working with a farmer is to develop a friendship and understanding, and then secure his interest, cooperation, support, and assistance. The farmer must be regarded as a resource person and not someone who needs to be taught or shown how to do the job properly.

When you are working with a farmer to help him overcome production constraints and improve his yields and income, he must be involved in the problem-solving exercise and decision-making process from the very beginning. Extension staff often think <u>they</u> know why a farmer is not getting good yields. Problems that the extensionist sees as important are not seen as important by the farmer, as the farmer's perception of constraints are not motivated by the same biological information.

When going to a farm, always prepare your visit well beforehand so that the farmer knows when you are going to arrive. It is no use "dropping in" on a farmer who is in the middle of something very important on his farm. Also prepare for your visit and work out what you actually want to achieve. The visit must be structured and undertaken for definite reasons; if the objective is not clear, you are wasting your time as well as the farmer's.

Never meet with the farmer in the village market or in his house if you want to discuss the potato crop growing in the field. When possible meet on the farm where you can relate to things that are happening around you--even if they involve crops other than potatoes.

The farmer must not get the feeling that he is being interviewed or questioned about how and why he does certain cultural practices or other farm operations. Do not approach him with your notebook and pencil in your hand, ready to write down everything that he says. This behavior can be threatening. By talking to the farmer and asking the right sort of questions, you will be able to build up a picture of how the crop is grown and what problems are encountered during the growing season, at harvest, in storage, and with marketing. If you can remember and write down the information afterwards, this is the best method. If there are facts and figures that you are not likely to remember, jotting down a few notes will not be seen as aggressive questioning. Do not ask the farmer, "Do you think that something or other is a problem?" Let the farmer do the talking and tell you what he believes are the problems. It is very easy to put ideas into someone's head and words into someone's mouth. The farmer may agree with you because he thinks that you should know what is right and what is the best solution. An extensionist has to be a good listener!

Once you understand the production system, you can then decide whether any of the cultural practices are wrong--based on the knowledge that you now have about the crop. Remember that the farmer may be doing something that you consider wrong because of economic and social reasons--not biological ones.

Diagnosis of limiting factors does not necessarily lead to identification of the solutions. The solutions may require inputs that are not available or are too costly. Solutions should be based, where possible, on modifications of existing technology or based on generation of new low-cost alternatives. Experience has shown that farmers easily adopt simple (single) changes but rarely complex technological packages designed to solve many production problems. It is best to take one step at a time.

Any ideas that you have about using different methods or materials to improve a crop have to be eventually tested and evaluated on-farm, through trials and demonstrations. These trials must be carried out by the farmer in the normal course of his farming operations. The farmer must understand what he is doing and why he is doing it. The motivation to cooperate in, for example, testing a new variety must be because he understands its potential for giving him better yields, and not because he is getting free seed and fertilizer to carry out the trial.

The farmer's evaluation of an alternative technology is as important as one based on agro-economic figures and calculations. His perceptions and opinions are essential, and should be sought whenever possible.

ON-FARM TRIALS WITH VARIETY DIAMANT

Planting

The extension agent should be with the farmer at the time of preparing the cut seed tubers and at planting, but the farmer must be allowed to follow his normal practices. Even if he is cutting the tubers wrongly or too small, he should not be corrected as we are interested to know how Diamant compares with the farmer's variety under normal farming conditions. All cultural operations must be those that the farmer practices.

If the farmer applies farm yard manure (FYM), this should be applied to all the potato field including the plots in the trial. If the farmer applies any of his own artificial fertilizer, this should NOT be applied to the plot of Diamant NOR to the plot of the farmer's seed that is included in the trial.

Mark off two 500 m^2 plots and apply the fertilizer. Remember that only 1/4 of the urea should be applied with the DAP. The remainder will be applied at ridging. One plot will be planted with Diamant and the other with the farmer's own tubers.

Let the farmer plant the tubers and carry out all operations. If the cut tubers of Diamant are sufficient to plant more than the 500 m^2 plot, the extra tubers can be planted outside the plot.

If the tubers are not enough to plant the whole plot (say, only 400 m^2 or 450 $m^{2)}$, make certain that the plot of the farmer's seed is exactly the same size. Remember that the amount of urea for the second application at ridging up is sufficient for 2 x 500 m^2 plots.

Another plot in the farmer's field that has only received the farmer's manure/fertilizer and not any DAI fertilizer should be marked out. At harvest, this plot will give us an estimate of the yield that the farmer gets over all his field.

The three plots, of equal size, that will be harvested are:

1. Diamant that received DAI fertilizer.

2. Farmer's variety that received DAI fertilizer.

3. Farmer's variety that received the same treatment as all the other parts of the farmer's potato crop.

4. Seed Improvement

4.1 Introduction and testing of variety Diamant

4.1.1 In the consultancy report of July/August 1991, it was suggested that a program be set up to introduce a new variety to farmers in Afghanistan as a possible replacement for the local varieties Garma and Sarda, stocks of which are now degenerate. The high level of virus diseases is one factor responsible for low productivity levels. Following discussions with staff of the Pakistan-Swiss Potato Development Project (PSPDP) in Islamabad, it was decided to test, in the first instance, the variety Diamant as it had shown very promising results in the hill areas of NWFP. Yields of over 40 t/ha have been recorded.

4.1.2 Last year it was agreed that on-farm trials would be carried out with five farmers in each of the following provinces: Wardak, Logar, Ghazni and Paktika. With the recruitment of more extension staff, the plan has been extended to cover Bamiyan and Parwan provinces. The inclusion of Bamiyan is heartening as this province is the major potato-growing area with some of the best potato farmers. The total number of sites for testing Diamant will now be 30.

4.1.3 The on-farm trial/demonstration plots will be planted at the following locations:

Wardak Province

Chak district	2 plots
Dimirdad sub-district	1 plot
Sayedabad district	2 plots

Logar Province

Kalangar district main potato area	2 plots
Baraki Barak district	1 plot
Chark district	1 plot
Khosi sub-district	1 plot

Ghazni Province

Central part of Kushk area	1 plot
Khoja Omri district	1 plot
Jaghotu district	1 plot
Qara Bagh district	1 plot
Mokur district	1 plot

List of observations

1. Name of farmer

2. Location of farm

3. Number of jeribs of potatoes

4. Number of years that the farmer has grown this particular stock, i.e., when did he last purchase seed tubers

5. Name of variety

6. Storage method used if farmer's own seed

7. Physiological condition of seed at planting

8. Distance between rows and distance between plants in the rows

9. Size of the whole tubers/cut tuber pieces planted

10. Date of planting

11. Date of emergence (when approx 90% of plants emerged)

12. % emergence (count a few sample rows and note number of missing plants. Calculate % emergence)

13. Date of final ridging/second application of urea

14. Stem density when the plants are about 30-40 cm high (count the number above-ground stems in 4 randomly selected rows, each of 10 m)

15. During the growing season, observations on crop growth and diseases (to compare the two varieties)

16. Dates when each of the two varieties are maturing (foliage turning yellow and plants beginning to die)

17. Date of harvest. (Each variety should be harvested when it is mature. This may mean that they are harvested at different times. The full potential of each variety must be achieved).

18. Total yield from each plot

19. Yield of marketable tubers from each plot

20. Storage method employed if not detailed in No.6 above

Frequency of irrigation may be noted, but this information is not important since the two varieties will receive the same treatment.

PIT STORAGE OF POTATOES

More precise information on pit storage is needed from all the potato-growing areas where this method is practiced. The extension agents should collect information about the different types of construction and operating procedures. It would be good if sketches could be made to supplement their notes. The kind of information required is:

1. Is the type of pit typical of the area?

2. Size of pit: width, length and depth. If round, diameter and depth

3. Capacity in kharwar/seers. Depth of potatoes in the pit.

4. Use of other materials e.g., wood, straw, etc., and how used.

5. Covering: depth of soil, shape (to effect run-off of water.

6. Ventilation. Is the pit completely closed? Are chimneys used for ventilation? If so, how many and diameter. Is there any ventilation, i.e., a way for air to enter the pit (as opposed to the chimneys to allow air to escape)?

7. Where are the pits sited? In the field or farm compound?

8. What is the soil structure? Sandy, sandy-loam, clay, etc.?

9. What is the air temperature during the storage period? Is there any snow (to act as an insulation)?

10. What is the normal length of storage? When are the pits filled and emptied?

11. During storage, does the farmer open up the pit to removed rotten tubers? If so, when is this usually done? Is the pit covered as previously or is the covering modified after inspection?

12. Are the tubers wet when the pit is emptied? In heavy soils, is there any free water at the bottom of the pit?

13. What is the farmer's estimate of average losses?

14. What is the average length of sprouts when the pit is emptied? Less than 5 cm, more than 5 cm, more than 10 cm? Does the farmer remove all the sprouts?

15. After emptying the pit, selecting tubers and desprouting, are the tubers planted straight away or kept for some time before planting? If kept, for how long and how are they stored?

Paktika Province

Sharan Central part	3 plots
Kolagu district	2 plots

Bamiyan Province

General part main potato-growing area	2 plots
Kamard district	1 plot
Saighan sub-district	1 plot
Shabur sub-district	1 plot

Parwan Province

Ghorband district	2 plots
Shakali sub-district	1 plot
Shurk Parsaw district	1 plot
Seeyagard sub-district	1 plot

4.1.4 Details of the plot size and quantity of seed tubers and fertilizer needed for each trial are given in the 1991 Report, paragraphs 2.3.3 and 2.3.4. Details for laying down the trial, data to be collected, and observations made during the cropping season are given in Annex III. Each extension agent responsible for a trial will receive a further briefing and written instructions.

4.1.5 Purchase of Diamant seed

4.1.5.1 There has been some concern over the availability of seed tubers of Diamant. The original idea that Mr Faizullah Khan, virologist at the Vegetable Seed and Potato Seed Farm at Quetta would arrange for the material on behalf of DAI from Jaffer Brothers (Private) Limited in Lahore and store it in Quetta (see 1991 Report, paragraphs 2.3.5 and 2.3.6) was dropped as he was not able to purchase the seed. Although a visit was made by DAI staff to Jaffer Brothers towards the end of last year and 3.5 tonnes promised from the February harvest in the Punjab, Jaffer Brothers have not confirmed this in writing.

4.1.5.2 The Production Manager, Mr Khalid Farooq, presently on a field trip to Gilgit, was contacted on February 17. Khalid Farooq worked for PSPDP in Kalam, Swat Valley for a number of years. Technically, he is a very sound person whose opinion I respect and value. He informed me that the Diamant crop matured at the end of January but could not be dug until mid-February because of the wet soils after the recent rains. He said that dormancy is 60-70 days and that the tubers will be in good physiological condition to plant in Afghanistan in May. In storage trials that he carried out in Kalam, it was possible to

keep Diamant in pits from the end of October until the first week of April. This would indicate that pit storage of this variety in Afghanistan is possible. He suggested that DAI staff visit Lahore (he will not be back in Lahore until February 23/24) to see the produce and make arrangements for collection. He also indicated that any feed-back of information from Afghanistan on the performance of the crop can be discussed with him and help sought, if necessary. When Dr Don Oelsligle and Abdullah Naik visit Lahore, they should take the opportunity of discussing pit storage problems with Khalid Farooq, as he might be able to provide some input based on his experience in Kalam.

4.1.6 Because the farmers' own seed potatoes and the Diamant seed tubers have been grown under different environmental conditions and storage has been different, the physiological ages of the materials will not be the same. This will have an effect on the yield potential, and therefore the first season of testing is not the best comparison of the two varieties. A truer picture of Diamant's performance will be seen in 1993 after it has been kept by farmers in pit stores throughout the winter. Valuable information on its post-harvest performance and storability under local conditions will be gained.

4.1.7 I am still of the opinion that it is correct to start with testing only one variety that we know will fit into the agro-ecological zones of Afghanistan. However, there is no way of knowing if it will be accepted, without reservation, by farmers and consumers. Farmers' acceptability of the newly introduced variety can be measured by their willingness to continue to grow it and replace part or all of their existing potato stock of the traditional varieties. It is not intended to sell any of the harvest and therefore it will not be possible to get a measure of the market response to Diamant. The farm family must be asked to cook some of the potatoes to find out if they are acceptable from the flesh color and palatability standpoint. The amount of work (data collection and observations) and time involved in carrying out this one trial with farmers is sufficient within the already heavy work schedule of the extension agents. Their overloaded program is of some concern to me.

4.1.8 It is recommended that the extension agents use the on-farm trial as a demonstration to other farmers in the area. They should visit the crop during the growing season and again at harvest when they can see the quality of the tubers.

4.2 Improving farmers' seed potato stocks

4.2.1 Some of the extension agents were briefed during a field visit to Swat in August 1991 about the procedures used for selecting healthy-looking plants in a farmer's field in order to reduce the percentage of tuber-borne diseases (especially those caused by viruses) in subsequent crops. This approach to seed improvement at farm-level was covered in detail during the training course and is explained, step by step, in the 1991 Report, section 2.2 "Improving seed tuber quality: the seed plot technique."

4.2.2 During the 1992 season, it is hoped that farmers can be motivated to start this program to improve the quality of their Sarda or Garma seed stocks that they store after harvest and use to plant the following year's crop. Those farmers that realize the benefit of good quality seed tubers will be more ready to accept the extra effort that is required. From a logistic and work program standpoint, it would be easier to cooperate with those farmers that are undertaking the variety assessment trial.

4.2.3 A booklet on potato production, written in Farsi last year by DAI staff, explains this methodology for improving seed tuber quality. All the extension agents have received a copy of this publication.

5. Storage

5.1 Traditionally, farmers in the highland areas where there is heavy snowfall and very low temperatures store potatoes throughout the winter in pits in the ground. As in other parts of the world, this is the only method available to small, resource-poor farmers.

5.2 At harvest , farmers market 50 per cent or more of their produce. The rest is stored in pits either for seed for the following crop or for sale for consumption in the spring. Potatoes that they want to use on a regular basis for the family are stored in their houses.

5.3 Pits are simple holes dug in the ground, usually to a depth of at least 1 m, and are large enough to contain from 1-2 t up to 6 t. (One tonne of tubers occupies a volume of 1.5 m^3). In cross section, pits are either round, square, or rectangular. The tubers are placed in the bottom of the pit to a depth of no more than 50 cm and then covered with soil. Some farmers may put a few

inches straw on the top of the potatoes before the covering of soil, but this is not a common practice. At ground level the soil is shaped like a mound to help run-off of water and lessen the chances of seepage into the pit.

5.4 Ventilation in stores is needed to remove heat, water and carbon dioxide, and to supply oxygen. Natural or forced draught ventilation can be used to ensure that air passes over the tuber surfaces. Natural ventilation of pit stores that are completely closed is not possible, and overheating occurs. This results in heavy losses due to rotting.

5.5 Progressive farmers in Bamiyan and Wardak Provinces incorporate chimneys into their pit stores to allow the hot air to escape, but air movement is restricted. The chimneys are made of wood, are the equivalent to 10-15 cm diameter, and extend up to 50 cm above the soil covering the pit. It is not known if use is made of the 10-cm diameter metal chimneys that are used in houses for heating stoves; these would be perfectly adequate.

5.6 In Wardak, some farmers leave an air space above the potatoes, place wood at ground level and then cover with soil. Even with the this system the movement of air is completely passive, and relies on the principle that hot air rises.

5.7 In Bamiyan, farmers dig pits 1-1.5 m wide and 10 m long. A wooden door is placed at one end and steps cut into the ground to get down to the base-level of the pit. The potatoes are placed in the bottom of the pit and covered with soil, as previously described, and three chimneys at fitted at regular intervals along the length of the pit. The space outside the pit, at the end with the door and where the steps cut into the ground, is covered with wood. When the outside air temperature is not too cold, the covering is removed to allow air to pass into the pit via the door. This method allows through ventilation and reduces losses. Losses are greatest at the end of the pit furthest from the door because the air cannot circulate completely throughout the bottom layers of the potatoes. The construction could be improved by placing the tubers on a raised, slatted-wooden floor to allow free circulation of air through the entire pit. It is recommended that this idea is tried with some farmers in Bamiyan and that this type of construction be demonstrated in other major potato-growing areas.

5.8 The extension agents are being asked to collect information and data from farmers during the coming

AFGHANISTAN AGRICULTURAL SECTOR SUPPORT PROJECT

PRIVATE SECTOR AGRIBUSINESS (ASSP/PSA)

POTATO PROGRAM DEVELOPMENT

Prepared for

OFFICE OF THE AID REPRESENTATIVE
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Prepared by

Garry Robertson

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